Agricultural Water Use
Overview

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Part I

“What We Did”

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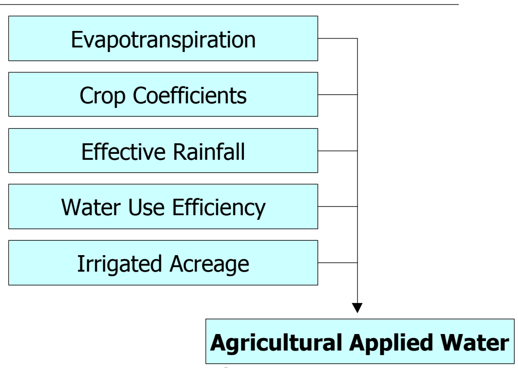
This section highlights the methods used in the development of Bulletin 160-98. It is intended to provide base information for Advisory Committee use in the 2003 Water Plan Update Process. It is not intended to be a roadmap of what will or should be done in the 2003 update.

Bulletin 160-98 Ag Water Use



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The California Water Plan's estimates of agricultural water use are derived by multiplying water use requirements for different crops by their corresponding irrigated acreage, and summing the results to obtain a total water use for irrigated crops in the State. This presentation provides an overview of the various inputs to the process, including evaporative demand, crop coefficients, effective rainfall, and water use efficiency.

The process for forecasting irrigated acreage is explained in the Land Use discussion paper.

Evapotranspiration

- Combination of two process
  - Evaporation
  - Transpiration
- Estimated by ET/evaporation method
  - Agroclimate stations
  - Pan evaporation correlates to crop ET

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Evapotranspiration (ET) is a measurement of the amount of water used by plants and crops. This term comes from the words *evaporation* (evaporation of water from the soil and from plant surfaces) and *transpiration* (transpiration of water by plants).

For planning purposes, the Department uses the ET/evaporation method to estimate growing season ET of specific crops. Concurrent with field measurement of ET rates, the Department developed a network of agroclimate stations to determine the relationship between measured crop ET rates and pan evaporation.

Data from these agroclimate studies verified that evaporation from a standard water surface closely correlates to crop ET.

Crop Coefficients

- Relate pan evaporation to crop ET
- $ET_{crop} = (E_p \times K_p)$
  - where:
    - Et_{crop} = crop evapotranspiration
    - E_p = pan evaporation
    - K_p = crop coefficient applied to pan evaporation

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Different plants have different water requirements, so they have different ET rates.

The water requirements of specific crops can be calculated as a fraction of pan evaporation. This fraction is the called the crop coefficient. Crop coefficients vary depending on the type of plant, stage of growth, when the crop is planted and harvested, and the climate of the agricultural region.

Effective Rainfall

- Rainfall beneficially used
- Limited according to:
  - soil characteristics
  - crop rooting depth

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Part of a crop's water requirements can be met by rainfall. The amount of rainfall beneficially used for crop production is called effective rainfall.

Precipitation stored within the crop root zone and not exceeding the available soil moisture holding capacity of the soil may become effective rainfall.

Effective rainfall is determined through soil moisture balance studies.

Evapotranspiration of Applied Water • $ET_{AW} = ET_{crop} - R_{eff}$ • where: • ET_{AW} = evapotranspiration of applied water • Et_{crop} = crop ET • R_{eff} = effective rainfall • "Per-acre" basis 7	In the arid west, rainfall is often insufficient to meet crop water needs so that irrigation, or applied water, is required to satisfy the remainder of the crop water requirement. The portion of ET met by irrigation is evapotranspiration of applied water. ET_{AW} is quantified on "per-acre" basis. The concept of ET_{AW} is important because it represents the basic supplemental water requirement of irrigated crops. Of course, we must apply more water than required to meet ET_{AW} because of variability in the soil, inefficiencies inherent in all irrigation methods, and the need to meet cultural water requirements such as for leaching soluble salts from the crop root zone.
Agricultural Water Use Efficiency • Efficient Water Management Practices • Efficiency depends on suppliers and users • EWMPs help suppliers better serve users • Improved water service leads to better on-farm efficiency 8	Bulletin 160-98 assumed statewide implementation of the agricultural Efficient Water Management Practices by 2020. Water savings due to EWMPs is quantified on the basis of expected improvements in distribution uniformity and seasonal application efficiency. EWMPs are based on premise that maximum agricultural water use efficiency depends on the actions of both water suppliers and users. The primary objective of the EWMPs is to help water suppliers better serve growers with more reliable, flexible water service. In turn, farmers can leverage enhanced water service to improve irrigation scheduling to best meet crop water requirements (irrigate only water when the crop needs it -- not just because water won't be available for the next several days), optimize the irrigation system and method for the specific crop and soil, and gain additional flexibility in crop selection.
Agricultural Water Use Efficiency • Distribution Uniformity • "Even-ness" of irrigation • Determined by "low quarter" method • Subject to soil, slope, and hardware constraints • Limiting factor for efficiency • 2020 DU 80 percent statewide 9	Distribution uniformity describes the "evenness" of irrigation water application. It measures the variation in the amount of water applied to the soil throughout the irrigated area It is determined using the "low quarter" method, by comparing the average amount of water infiltrating the quarter of the field receiving the least water from the irrigation system, with the average applied to the entire field. For Bulletin 160-98, it was assumed that by 2020 it may be possible to achieve distribution uniformities of up to 90 percent, and averaging about 80 percent statewide.

Agricultural Water Use Efficiency

- SAE = (ET_{AW} + LR) / AW
  - Where:
    - SAE = seasonal application efficiency
    - ET_{AW} = evapotranspiration of applied water
    - LR = leaching requirement
    - AW = applied water
- Based on amount of water required for sustainable agriculture
- Limited by DU

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Seasonal application efficiency is the sum of ETAW and leaching requirements divided by applied water

It is an appropriate index of water use efficiency for planning purposes, because it's based on the amount of water required to fully satisfy crop water needs while maintaining a favorable salt balance in the root zone for long-term sustainability of agriculture

Optimal SAE occurs when the very driest part of the field receives an amount of water equal to ET_{AW} plus leaching water requirements -- a 100 percent effective irrigation.

Bulletin 160-98 assumed a statewide average seasonal application efficiency of 73% by 2020, based on the underlying assumption of 80% distribution uniformity and 100% effective irrigation.

Unit Agricultural Applied Water

- Irrigation water to satisfy:
  - ET_{AW}
  - Leaching requirements
- "Per-acre" basis
- AW = (ET_{AW} + LR) ÷ SAE
  - Where:
    - AW = applied water
    - ET_{AW} = evapotranspiration of applied water
    - LR = leaching requirements
    - SAE = seasonal application efficiency

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Unit applied irrigation water is quantified on "per-acre" basis. Applied water is determined by summing the water needed for ET_{Aw} and leaching requirements, then dividing by a measure of irrigation efficiency in order to account for the water lost during the irrigation process.

Leaching water is used to remove soluble salts from the crop root zone. The amount of water required for this use depends upon the crop, irrigation water quality, and soil characteristics (e.g. texture, depth).

Agricultural Applied Water (AW)

- Unit AW multiplied by crop irrigated acreage
- Based on "normalized" ET_{AW} data

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To determine agricultural applied water, unit applied water use values for specific crop groups are multiplied by the appropriate irrigated acreage. The base year applied water use values for Bulletin 160-98 were computed from normalized ET_{AW} data to account for variation in annual weather patterns and water supply. Normalizing entails applying crop coefficients to long-term average evaporative demand data.

Actual applied water use during a wet year would likely be less than the base year value due to increased effective rainfall, and possibly lower evaporative demand. Likewise, actual applied water use during a dry year would likely exceed the base due to less than average effective rainfall with an attendant increase in crop ET_{AW}.

Part II "What We Heard" General Issues and Comments Regarding Bulletin 160-98 13	This section was drawn from comments received during either the 1999 workshops on B160-98 or the 2003 Water Plan Update scoping workshops held in early 2000. (The complete list was presented to you in your January 18, 2001 meeting materials) The section is meant to capture the range of perspectives that were offered by the public during those sessions. Many of these comments present significant matters for the Department and the Advisory Committee to discuss. The comments, however, come from vastly different, and occasionally even mutually-exclusive, perspectives, on how the 2003 Update could be or should be changed from the 1998 version. Inclusion of the comments should not be seen as an endorsement by the Department of the comment or agreement with its underlying premise, other than as a starting point for potential dialogue.
Reviewer Comments • Update K_p values • Separate "E" and "T" • Estimate "E" by crop and irrigation method • Evaluate crop water use by irrigation method 14	Reviewer Comments: The Department should update crop coefficient values. Evaporation and transpiration should be analyzed separately, and evaporation should be reported as a function of crop type and irrigation method. Agricultural water use estimates should be based on the distribution of irrigation methods by crop type, and the potential for changing the methods of irrigation by type of crop (instead of using a crop coefficient method).
Reviewer Comments • Better account for leaching water requirements • Assume SAE of 80 by 2020 • Assume demise of gravity irrigation methods 15	Reviewer Comments (continued): DWR should better account for the water used to leach salts from the soil profile. The 73% statewide average seasonal application efficiency to too low. A better assumption is 80% SAE by 2020. There has been significant change in irrigation types used in California, and there is vast potential for further improvements in precision irrigation in the future. Bulletin 160 should assume that surface irrigation methods will be replaced with more efficient sprinkler and drip based irrigation for agriculture in future years.

Reviewer Comments • EWMPs are limited in scope • Wholesale adoption of EWMPs is overly optimistic • 80% DU by 2020 is overly optimistic. • Make underlying data readily available 16	Reviewer Comments (continued): B160-98 understated conservation, because future demands were reduced only by the estimated amounts of conservation for the Efficient Water Management Practices. The current EWMPs are limited in scope and may exclude many other cost-effective actions. The assumption that statewide average distribution uniformity will improve to 80 percent by 2020 may be overly optimistic. The Department should make agricultural water use data readily available to the public.
Reviewer Comments • Consider CVPIA water conservation plans • Consider tiered pricing • Water demand is not independent of price • Forecast water use price increases 17	Reviewer Comments (continued): Water conservation potential should include consideration of CVPIA water conservation plans and tiered water pricing Bulletin 160-98 incorrectly assumes that water demand is independent of price. Forecasted water use ought to consider future price increases.
Reviewer Comments • Assessment of conservation potential is realistic • Conservation potential is much greater than is shown 18	Reviewer Comments (continued): Bulletin 160-98 provides a realistic assessment of water conservation potential The potential for water conservation is much greater than is shown in Bulletin 160-98.

Part III "What We Would Like Early Input On" (Policy, Process, and Resource Issues) 19	This section lists issues that the Department believes need to be addressed relatively early in the update process, particularly in light of the Department's statutory requirement to release, by January 1, 2002, a preliminary draft of the "assumptions and other estimates upon which the [2003 Update] will be based." (See Water Code Section 10004.6, distributed in your 1.18.01 meeting binder). At the March 8, 2001, Advisory Committee meeting, Advisory Committee members will have the opportunity to discuss this list and make their own suggestions for additions or modifications.

Issues for Early Advisory Committee Consideration
 	
• Methods for estimating:
  • Base year mix of irrigation methods
  • Base year on-farm irrigation efficiency
  • Forecasted mix of irrigation methods
  • Forecasted on-farm irrigation efficiency
 	
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	Regional irrigation efficiencies depend on the existing mix of irrigation methods. What is the best way to estimate current conditions?
	
	Applied water values are derived, in part, on estimates of irrigation efficiency. What is the best method to characterize current irrigation efficiencies by crop type and region based on real world information, including knowledge of operating conditions and on input from farmers and farm advisors?
	
	What will be the mix of irrigation methods in the future, considering expected costs of inputs (e.g., water, energy) and crop markets?
	
	What is the best way to forecast on-farm irrigation efficiency? Beyond mix of irrigation methods and crop types, what assumptions should be made about future conditions (e.g., financial incentives)?